Chapter 17

AN ONTOLOGY-BASED EXPLORATION OF KNOWLEDGE SYSTEMS FOR METAPHOR

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Abstract: This chapter takes the complex knowledge systems of metaphors and shows that their structured knowledge can be represented and predicted by ontology. The complex knowledge system of metaphors contains two knowledge systems, source domain and target domain, as well as the knowledge mapping between the two domains. Hence metaphors offer a test case of how structured knowledge can be manipulated in an information system. In terms of the theory of metaphor, we integrate the Conceptual Mapping Model with an ontology-based knowledge representation. We demonstrate that conceptual metaphor analysis can be restricted and eventually, automated. In terms of knowledge processing, we argue that the knowledge structure encoded in ontology, such as the Suggested Upper Merged Ontology (SUMO), is the necessary foundation for manipulating information from multi-domain and multilingual sources. We first extract source domain knowledge structure based on ontology. Next we show that the ontological account allows correct explanation of the parallel yet different use of the same source domain in two different languages. Thirdly, we showed that the restricted set of upper ontology can be combined with the open lexical knowledgebase of wordnets to provide a principled, yet robust, general coverage of language-based knowledge systems.

Key words: conceptual mapping; corpus; knowledge system; metaphor; ontology; suggested upper merged ontology, wordnet

1. BACKGROUND

Computational ontology can provide information systems with the structure to acquire and organize information. [1] Even though the programmatic nature of computational ontology is well-suited to providing a uniform platform for information integration, they also face the challenge of how to accommodate information from different and possibly conflicting conceptual systems. One difficult case involves metaphors. Since metaphors are familiar, concrete terms used to describe abstract concepts; they necessarily involve more than one conceptual system.

In this chapter, we refer to any information source with inherent conceptual coherence as a **knowledge system**. We will show that ontology are up to the challenge to represent different knowledge systems. In particular, we apply SUMO (Suggested Upper Merged Ontology) [1] to explore the complex knowledge systems involved in comprehending metaphor. We will demonstrate that, based on corpus data, ontology can be applied to discover and define the source domain knowledge in metaphors. Finally, by utilizing its inherent logical inference structure, we show that ontology allows a principled way to postulate conceptual mappings that bridge the complex knowledge systems of metaphor.

We adopt John F. Sowa's definition of ontology as 'a catalog of the types of things that are assumed to exist in a domain of interest ***D*** from the perspective of a person who uses a language ***L*** for the purpose of talking about ***D***.' [2] A computational ontology is a computational implementation of such an ontology. A computational ontology typically contains a list of atoms as well as their relations. It is important to note that in this definition, ontology is language-based and domain-specific, although it does express the shared conceptualization of that specific domain given the language.

Sowa's definition of ontology allows its use in the Semantic Web [3], where each web resource is required to have its own ontology to explicitly state the conceptual structured used in that resource. It also underlines the need to have a shared upper ontology where representations of individual ontology can be uniformly described and unified. This provides the basis for knowledge sharing.

We propose a new approach to conceptual metaphors in this chapter. The new approach incorporates two computationally trackable elements. First, the data analysis is corpus-based, following the example of MetaBank [18]. Second, the representation is ontology-based. Both elements strengthen our Conceptual Mapping and Empirical Prototype account of metaphors.

[1] Here we adopt the definition from http://www.projectauditors.com/, (omissions ours) that an information system is 'a structured, interacting, complex of persons, machines, and

2. KNOWLEDGE SYSTEMS: MOTIVATION AND THEORETICAL PREMISES

In order to gather and use information from multiple sources, the information must be correctly aligned and uniformly represented. In addition, it must be recognized first that these pieces of information come from different knowledge systems and have their own conceptual coherence which may conflict with each other. Thus, two essential tasks are that information from compatible knowledge systems must be correctly synchronized and information from incompatible knowledge systems must be properly integrated with minimal loss of information. We also need to recognize that information must be situated in a knowledge system in order to be useful. One of the most efficient ways to situate information is to put it in a well-structured and complete knowledge representation system, such as a computational ontology. In sum, information can only contribute to a decision making process when it is correctly interpreted given the presuppositions and logical entailments encoded in the knowledge system. In what follows, we will describe the knowledge systems that are used in this study.

2.1 Corpora and WordNet: Two kinds of linguistic knowledge systems

Human beings are agents in decision making as well as important sources of information; while language is the definitive human tool for expressing and storing information. Hence, the focus of this study is on language as a knowledge system.

There are two ways to look at language as a knowledge system. The first is to look at the accumulative data of language use as a collection of knowledge with implicit structure. This is the corpus-based approach, where corpus is defined as a set of electronic texts collected under a set of design criteria. The second is to explicitly encode linguistic relations in a language resource. One typical approach is to encode the semantic relations among all words in a language. These words form a network built on a set of pre-defined logico-linguistic relations. This is the wordnet approach. It is important to note that, in either linguistic approach, the theoretical premise is that words are linguistically instantiated conceptual atoms; hence the collection of all words in a language is the shared and complete set of conceptual atoms of people using that language. Thus wordnets are the representation of a linguistically instantiated knowledge systems, while corpora are collections of instantiated instances of a knowledge system.

The first and prototypical wordnet is English WordNet.[2] WordNet is a lexical knowledgebase for English language constructed by the Cognitive Science Laboratory of Princeton University in 1990 (http://wordnet.princeton.edu/index.shtml, [4]). Its content is divided into four categories based on psycholinguistic principles: nouns, verbs, adjectives and adverbs. WordNet organizes the lexical information according to word meaning and each synset contains a set of lemmas (i.e. word forms) sharing the same sense. Notice that each lemma instantiates one or more senses. In addition, WordNet is a semantic network linking synsets with lexical semantic relations. WordNet is widely used in Natural Language Processing applications and linguistic research. The most updated version of WordNet is WordNet 2.0. We adopted WordNet 1.6, the version which is used by most applications so far.

2.2 Metaphor: A Complex Knowledge System

A metaphor is given the definition of 'a figure of speech in which an expression is used to refer to something that it does not literally denote in order to suggest a similarity' by WordNet 1.6. In use, the expression chosen is often familiar and concrete, and the figurative meaning abstract. There are two main approaches to metaphor, namely the classical approach and the cognitive approach. The classical approach goes back to as far as 1960s in which metaphor was seen philosophers such as Black [5] and Searle [6] as a violation of the literal meanings The other approach, which is the cognitive approach, is based on the groundbreaking theory of conceptual metaphor by Lakoff and Johnson [7] who described the formation of a metaphor as a mapping from a source domain (i.e. the literal expression) to a target domain (the figurative reading). By this definition, metaphors are complex knowledge systems involving two knowledge domains. In addition to this main-stream theory, there are also other theories under the cognitive paradigm. Psycholinguists such as Camac and Gluckberg [8] and Gibbs [9] deal primarily with similarity-creation between the target and source domains. Works in this direction usually concentrate on discovering the similarities between linguistic forms such as that between two ideas, or words of the same forms (usually nouns) in a string of words [8] and two semantic domains [10]. However, what these works have in common is that they try to explain metaphors through linguistic similarities found within the two domains. One famous work in this direction is Gentner's [11] structure-

[2] Following convention, WordNet (with capitalization) is a trademarked proper name referring to the Princeton English WordNet. In this chapter, the non-capitalized 'wordnet' refers to WordNet-like lexical knowledgebases that were built later, including those for languages other than English.

mapping model in which attributes in two different domains are mapped onto one another to establish the link between the domains.

Since the diversities in approaching metaphors, different terms have been suggested to describe the mapping of the abstract to the concrete ideas. Among which are Richards's [12] 'Vehicle' (the Source) and 'Topic' (the Target), and Black's [5] 'Systems' to represent both source and target domains. For the convenience of description, this chapter will adopt Lakoff and Johnson's [7] definition of source and target domains to refer to the abstract and concrete ideas respectively.

From the point of view of information systems, metaphor presents itself as a perfect case for how to uniformly representing information from two different knowledge systems. Studies which attempt to represent figurative meanings in addition to the lexical meanings in electronic sources include Lönneker [13], Alonge and Lönneker [14] and Peters and Wilks [15]. All these works are concerned with making connection between the two knowledge systems so as when one system (such as literal one) is activated; the other system (such as the metaphorical one) will be activated as well. In this chapter, we propose an ontology based approach to the representation of information in this complex knowledge system.

The theory of metaphor by Lakoff and Johnson [7] has been the focus of study on lexical and figurative meaning for the past two decades. Are conventional conceptual metaphors a cognitive rather than a linguistic phenomenon? Work within Cognitive Linguistics would seem to say that this is the case. For example, Lakoff [16] writes with respect to the source-target domain mapping of the conventional conceptual metaphor LOVE IS A JOURNEY:

> Is there a general principle governing how these *linguistic expressions* about journeys are used to characterize love.... [Yes], but it is a *general principle* that is neither part of the grammar of English, nor the English lexicon. Rather it is *part of the conceptual system underlying English....* (Page 306, italics ours)

Thus, the onus of dealing with metaphorical meaning in the lexicon is not necessary. Metaphor may be treated at a different (i.e. higher) cognitive level.

But is it really the case that there are no general principles that can be extracted and proposed at the lexical level? The Conceptual Mapping (CM) Model [17] was proposed to constrain the Contemporary Theory of Metaphor [16]. This model analyzes the linguistic correspondences between a source and target (knowledge) domain in order to determine the underlying reason for the source-target pairings. The underlying reason is formulated in terms of a Mapping Principle. The theory also postulates a Mapping

Principle Constraint, which says that a target domain will select only source domains that involve unique mapping principles.

For example, Ahrens [17] points out that in the conceptual metaphor IDEA IS BUILDING in Mandarin, the linguistic expressions relating to the concept of foundation, stability and construction are mapped (i.e. are conventional linguistic examples) while concepts relating to position of the building, internal wiring and plumbing, the exterior of the building, windows and doors are not (and these are the concepts that are in the real world knowledge of the source domain). Thus she postulates that the target domain of IDEA uses the source domain of BUILDING in order to emphasize the concept of structure. Thus, when someone talks about ideas and want to express positive notions concerning organization, they use the source domain of BUILDING. The Mapping Principle formulated in this case was therefore the following:

(1) Mapping principle for IDEA IS BUILDING: Idea is understood as building because **buildings involve a (physical) structure and ideas involve an (abstract) structure.** [17]

When IDEA is talked about in terms of FOOD, however, the expressions that are mapped are 'ingredient', 'spoil', 'flavorless', 'full', 'taste', 'chew', 'digest' and 'absorb'. Mandarin Chinese, in contrast with English, does not have conventional expressions relating to 'cooking' or 'stewing' of ideas. Thus, the postulated Mapping Principle is: Idea is understood as food because **food involves being eaten and digested (by the body) and ideas involved being taken in and processed (by the mind)** [17].

Thus, IDEA uses the source domains of BUILDING and FOOD in Mandarin Chinese for different reasons, namely to convey information related to 'structure' or 'processing' (i.e. 'understanding') respectively. Thus, it is similar to the Contemporary Theory of Metaphor in that it supposes that there are systematic mappings between a source and target domain, but it goes a step further in postulating an underlying reason for that mapping. The CM Model predicts that conventional metaphors, novel metaphors that follow the mapping principle and novel metaphors that don't follow the mapping principle will be rated differently on interpretability and acceptability scales when other factors, such as frequency are controlled for. This model is supported in psycholinguistic experiments because it correctly predicted the processing differences involved between conventional and novel metaphors [17].

2.3 The Conceptual Mapping Model and Ontology

The CM model of metaphor presupposes structured shared source domain knowledge. For a mapping to be conventionalized and understood by speakers, the content and structure of the source domain knowledge must be *a priori* knowledge and should not have to be acquired. How to define and verify such structured knowledge is a challenge to this theory. We attempt to meet this challenge in two ways: first, by assuming that the source domain knowledge representation is instantiated by a shared upper ontology, such as SUMO. If the source domain knowledge representation is indeed ontology-based, a natural *a priori* knowledge source for a mapping principle is the inference rules encoded on a particular conceptual node of SUMO. In order to verify such hypothesis, we can take a further step of examining actual mappings of linguistic expressions in the corpora, and extracting the most frequent mappings. We hypothesize that the underlining mapping rule is instantiated by the prototypical expression involving that metaphor. We call this account the Empirical Prototype account, since the mapping is empirically verified by identifying and account for the most typical instance of that metaphor. In practice, we predict that frequency of use in a newspaper corpus can be used to predict the underlying mapping principle.

The integration of an upper ontology to the CM model has the following theoretical implications: First, the source domain knowledge representation is now pre-defined and constrained. Second, the validity of such a hypothesis will in turn support the robustness and universality of the proposed upper ontology.

3. RESOURCES

Our study concentrates on linguistic data since it offers the richest source of human-oriented information. In particular, all data are extracted from corpora, while the knowledge representation is obtained through both wordnets and ontology.

3.1 Corpora: Sinica Corpus, WSJ Corpus, and the Web

Corpora are a unique resource in knowledge engineering and central to recent developments in natural language processing. On one hand, they are attested and realistic linguistic uses and hence provide verifiable empirical foundation for research. On the other hand, they are large scale datasets that are both well-defined and sharable. Thus corpora provide the foundation for stochastic studies. In terms of information systems, corpora provide a test ground for how information can be gathered from actual and non-uniform language sources. We draw mainly on two corpora in this data. The primary source, since our study focuses on Mandarin Chinese, is the Academia Sinica Balanced Corpus of Modern Mandarin Chinese (Sinica Corpus, http://www.sinica.edu.tw/SinicaCorpus/). This is a tagged corpus of 5 million words of modern Mandarin usage in Taiwan. In our comparative work with English, we use the 1994 portion of the Wall Street Journal Corpus (WSJ Corpus). This can be accessed through the Linguistic Data Consortium (http://www.ldc.upenn.edu/ldc/online/index.html).

A new approach to corpus-based studies treats the World Wide Web directly as a corpus [21]. Since the web now is also the richest and most readily available source of information, this approach has strong implications for the constructions of future information systems. In this current study, we take the most fundamental step of supplementing data from the web when they were not attested in the corpora we use.

3.2 Princeton WordNet

The Princeton WordNet is the prototype of wordnets in the world. It is a monolingual wordnet that encodes lexical knowledge in terms of concepts and semantic relations. In WordNet 1.6., the version adopted in this study, there are 99,642 synsets. Each synset contains one or lemmas (i.e. word forms). There are in 174,007 synset to lemma mappings in total. Since a lemma can be mapped to more than one synsets and be polysemous, there are 122,864 unique lemmas in WordNet 1.6. The conceptual network of WordNet is build upon synsets as atoms and and linked with lexical semantic relations. WordNet encodes 11 different lexical semantic relations: synonymy, antonymy, hyponymy, hypernymy, troponymy, and three types of meronymy and holonymy. Synonymy is defined by members of the same synset, while hypernymy and hyponymy are encoded to form an inheritance tree. All other relations are encoded as a paradigmatic extension of the main tree. In our study, Princeton WordNet serves as a cross-lingual index of concepts as well as link to upper ontology.

3.3 Sinica BOW

The Academia Sinica Bilingual Ontological Wordnet (Sinica BOW, http://BOW.sinica.edu.tw) integrates three resources: WordNet, English-Chinese Translation Equivalents Database (ECTED), and SUMO (Suggested Upper Merged Ontology). This structure of the Sinica Bow can be seen in Figure 17-1. In this figure, the interface between the different electronic resources is shown through the connecting arrows between these resources. The three resources were originally linked in two pairs: WordNet 1.6 was

manually mapped to SUMO [22] and semi-automatically to ECTED. In fact, the 122,864 unique synset-lemma pairs are mapped to 195,817 words in Chinese. ECTED encodes both equivalent pairs and their semantic relations [23], hence offers a rich bilingual knowledgebase.

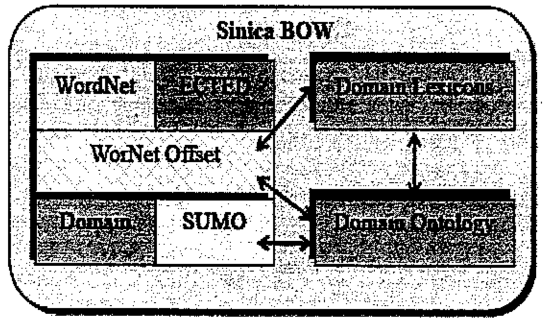

Figure 17-1. The resources and structure of Sinica BOW

With the integration of these three key resources, Sinica BOW functions both as an English-Chinese bilingual wordnet and a bilingual lexical access to SUMO. Sinica BOW allows versatile access and facilitates a combination of lexical, semantic, and ontological information. One of the new additions to Sinica BOW is a version comparison function between WordNet 1.6 and 1.7. Figure 17-2 shows a snapshot of the results yielded from the English keyword 'growth.' In Figure 17-2, the search results for 'growth' provide the WordNet senses in English as well as their translation in Chinese, with additional links to their related SUMO nodes.

It is important to note that the versatility of the Sinica BOW is built in with its bilingualism, and the lemma-based merging of multiple resources. First, either English or Chinese can be used for the query, as well as for presenting the content of the resources. Second, the user can easily access the logical structure of both the WordNet and SUMO ontology using either words or conceptual nodes. Third, multiple linguistic indexing is built in to

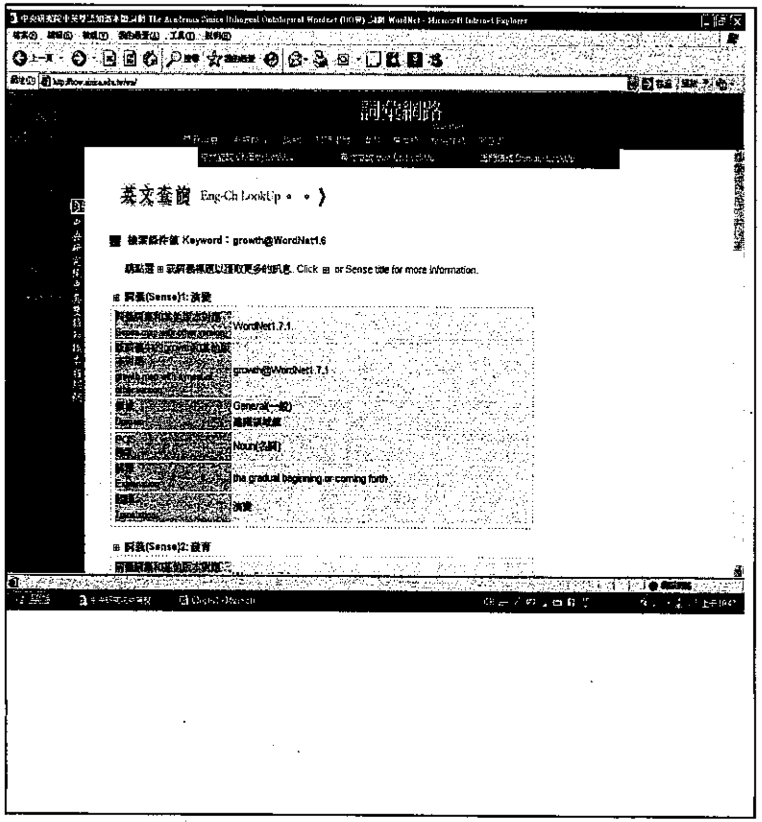

Figure 17-2. A Snapshot of the Sinica BOW

allow additional versatility. Fourth, domain information allows another dimension of knowledge manipulation. This function is crucial to our study on metaphoric systems. We use this bilingual ontological wordnet as a lexical knowledgebase to interface with the upper ontology of SUMO.

3.4 SUMO (Suggested Upper Merged Ontology)

Suggested Upper Merged Ontology (SUMO, http://www.ontologyportal.org) is a shared upper ontology developed by the IEEE Standard Upper Ontology Working Group. It is a theory in first-order logic that consists of approximately one thousand concepts and 4000 axioms. Each concept atom is well-defined and associated with a set of axioms for first-order inference.

It is well-defined with both a textual explanation for human use and a formal definition in the knowledge representation language of SUO-KIF. The axioms are also written in SUO-KIF. In is important to note that not all concept nodes have linguistic names, although linguistics names are used as mnemonics. A pair of good examples of linguistic and non-linguistic nodes is Object and CorpuscularObject, which happens to be a subclass of Object. The conceptual hierarchy of SUMO is built upon the traditional IS-A relations. However, there are two important design features that differentiate SUMO from more traditional ontology. The first is that it allows multiple inheritances to better represent human conceptualization. For instance, An Organism has two super-classes. It is both an Agent and an OrganicObject. A set of functions and relations that are considered atom and used in definition and axioms are also well-defined as part of the upper ontology. That is, SUMO is a self-contained upper ontology that is not dependent on other a prior conceptual structure.

For expansion, SUMO also contains a conformant middle level ontology (MILO) and domain ontology. Including domain ontology, SUMO contains more than 20,000 terms and more than 60,000 axioms. Its purpose is to be a shared and inter-operable upper ontology (Niles and Pease [24], Pease and Niles [25], Sevcenko [26]) Since ontology are formalized descriptions of the structure of knowledge bases, SUMO can also be viewed as a proposed representation of shared human knowledge, and thus a good candidate for mapping information about the source domain to the target domain. It can be applied to automated reasoning, information retrieval and inter-operability in E-commerce, education and NLP tasks.

The application of SUMO in knowledge engineering and in processing of lexical meaning is facilitated by its interface with WordNet.[3] Niles and Pease [12] mapped all synsets of WordNet to at least one SUMO term. This means that any word listed in WordNet is assigned a corresponding ontological location in the knowledge representation of SUMO. Through the encoded English-Chinese bilingual wordnet, Sinica BOW now allows mapping from a Chinese lexical meaning to a SUMO concept node. We use these mappings between lexical knowledge bases with ontology as tools to assign shared knowledge structure to unstructured multilingual information. It is important to note that both WordNet and SUMO are free resources. Combining the over 100,000 Enlglish WordNet and the over 20,000 conceptual terms or SUM O forms a formidable lexical knowledge resource. In addition, we have more than 150,000 Chinese translations linked to both English WordNet and SUMO.

4. FROM LINGUISTIC DATA TO SYSTEMIC KNOWLEDGE

In order to discover the knowledge system of metaphor as attested by corpus data, we first extract metaphoric uses from corpus and analyze them. We extract 2000 instances of *jingji* 'economy' from Sinica Corpus. Each of these 2000 was examined and all metaphorical instances were marked. (A metaphorical instance is defined as when an abstract concept such as 'economy' is discussed in terms of a concrete concept, such as 'building'.) All instances of concrete concepts were then grouped into source domains. All source-target domain pairings that had more than 20 instances were then examined. In Tables 17-1–17-4 below we show the source domains that were found for *jingji* 'economy' and we give the total number of instances and the number of tokens for each metaphor, as well as a proposed mapping principle based. Also note that the following mappings were manually analyzed and classified.

The most frequent mapping instance within a source domain indicates the basis of the reason for the source-target domain pairing, i.e. the mapping principle. We hypothesize that each source-target domain pairing will have a prototypical instance of mapping as evidenced by an individual lexical item that is highly frequent as compared with other mappings. In addition, we propose using an ontological-based knowledge representation, such as SUMO, to define and delimit the source domain knowledge in the CM Model. This has the advantage of using SUMO to infer knowledge through automatic reasoning, and as well as constraining the scope and falsifiablity of the conceptual metaphor.

We first note that the EP (Empirical Prototype) hypothesis holds up since in three of the four source-target domain pairings there are one or two lexical items that is/are obviously more frequent than the others (cf. Tables 17-1–17-4).

For example, for ECONOMY IS A PERSON, the mapping principle is postulated to have to do with the life cycle of a person (and not, for example, the mental health of a person) because of the frequent occurrence of the lexical item '*chengzhang*' (growth).

In the case of ECONOMY IS A BUILDING in Table 17-2 below, the mapping principle is postulated to having to do with structure, and not for example, leaky plumbing.

This is an interesting case because, as mentioned above, Ahrens [17] examined IDEA IS A BUILDING and postulated that the mapping principle also had to do with structure (i.e. the structure of a building and the structure of ideas). As Ahrens [17] points out, it is not always the case that different

Table 17-1. ECONOMY IS A PERSON (121 instances)
Mapping Principle: Economy is person because people have a life cycle and economy has growth cycle.

	Metaphor	Freq.
Entities	***chen2zhang3* (growth)**	**67**
	shuai1tui4 (regression/decay)	8
	chen2zhang3chi2 (growth period)	2
	ming4ma4i (lifeblood)	2
	bing4zhuang4 (symptoms)	1
Quality	*shuai1tui2* (weaken and degenerate)	1
Functions	*chen2zhang3* (grow)	21
	fu4shu1 (regain consciousness)	9
	shuai1tui4 (to become weaker)	5
	e4hua4 (deteriorate)	4
	hui1fu4 (recover)	1

Table 17-2. ECONOMY IS A BUILDING (102 instances)
Mapping Principle: Economy is building because buildings involve a (physical) structure and economy involves an (abstract) structure.

	Metaphors	Frequency
Entities	***jian4she4* (construction)**	**39**
	jie2gou4 (structure)	20
	ji1qu3 (foundation)	15
	gui1mo2 (model)	5
	gen1ji1 (foundation)	2
	zhi1chu4 (pillar)	1
	chu2xing2 (model)	1
Qualities	*wen3ding4* (stable)	8
	wen3gu4 (firm)	2
Functions	*chong2jian4* (re-build)	9

target domains use the same aspect of a source domain. For example, the source domain of FOOD is used differently for IDEAS (to express the notion of digestion and processing) as compared with LOVE which uses FOOD to compare different tastes to different feelings.

For ECONOMY IS A COMPETITION, shown in Table 17-3, the emphasis is on the strength of participant in order to defeat the opponent.

In ECONOMY IS WAR (Table 17-4), however, there is no clear-cut instance of a frequent mapping. We suggest that this is because WAR is a subset of the source domain of COMPETITION (i.e. a violent contest) in the SUMO representation, as discussed in section 5 below.

Table 17-3. ECONOMY IS A COMPETITION (40 instances)
Mapping Principle: Economy is competition because a competition involves physical and mental strength to defeat an opponent and an economy requires financial strength in order to prosper against other economies.

	Metaphors	Frequency
Entities	***shi4li4* (actual strength)**	14
	jing4zheng1 (competition)	12
	jing4zheng1li4 (power of competition)	3
	jing4zheng1you1shi4 (advantage in competition)	3
	ruo4zhe3 (the weak one)	2
	dou4zheng1 (a struggle)	2
	ruo4shi4 (a disadvantaged situation)	1
	qiang2guo2 (a powerful nation)	1
	tui2shi4 (a declining tendency)	1
Function	*shuai1bai4* (to lose)	1

Table 17-4. ECONOMY IS WAR (23 instances)
Mapping Principle: Economy is war because war involves a violent contest for territorial gain and the economy involves a violent contest for territorial gain and the economy involves a vigorous contest for financial gain.

	Metaphors	Frequency
Entities	*qing1lue4* (invasion)	4
	da4quan2 (immense power)	4
	zhan4 (battle)	2
	lao3bing1 (veteran)	1
	gung1fang3zhan4 (defend and attack battle)	1
	che4lue4 (tactics)	1
Qualities	*qian1chuang1bai3kong3* (one thousand boils and a hundred holes; holes all over)	1
Functions	*gua4shuai4* (to take command)	5
	quan2li4chong1chi4 (to dash with full force)	1
	(da1quan2) chao1zai4 shou3shang4 (to grasp the power)	1
	xi1sheng1 (sacrifice)	1
	xi1sheng1ping3 (victims)	1

In sum, the corpora data show that the use of metaphoric expressions is systematic. This supports the CM model's hypothesis that there is a subset of linguistic expressions within a particular source domain that map to a target domain. It is not the case that 'anything goes.' In fact, the corpora data presented above suggest an even more restricted view that there are usually one or two linguistic expressions that frequently map between the source and target domains and 'drive' the motivating relationship between them. In the next section, we look at whether or not the source domain knowledge can be defined *a priori* through an upper ontology such as SUMO.

5. STRUCTURAL REPRESENTATION OF SOURCE DOMAIN KNOWLEDGE

After showing that metaphor uses can be treated as a knowledge system governed by mapping rules, the next challenge is how to represent and verify the structured knowledge in a source domain. Since a shared upper ontology is designed to represent the shared knowledge structure of intelligent agents and allows knowledge exchange among them, we propose to adopt a shared upper ontology to represent the knowledge systems of metaphors. As mentioned earlier in this chapter, we adopt SUMO as our shared upper ontology.

In SUMO, conceptual terms are defined and situated in a tree-taxonomy. In addition, a set of first order inference rules can be attached to each conceptual node to represent the knowledge content encoded on that term. The conceptual terms of SUMO are roughly equivalent to the source domains in MP theory. Hence the well-defined SUMO conceptual terms are candidates for knowledge representation of the source domain in the MP theory of metaphor. In other words, SUMO provides a possible answer the question of how source domain knowledge is represented and how does this knowledge allows the mapping in conceptual metaphors. We examine how this might be possible by looking at two conceptual terms that are represented in SUMO and are related to our source domains – CONTEST and ORGANISM.

5.1 Economy is Contest

First, we found that what we intuitively termed as 'competition' above has a corresponding ontological node of Contest. The term Contest is documented as 'A SocialInteraction where the agent and patient are CognitiveAgents who are trying to defeat one another.' Its only axiom for inference is quoted here:

(=> (instance ?CONTEST Contest) (exists (?AGENT1 ?AGENT2 ?PURP1 ?PURP2) (and (agent ?CONTEST ?AGENT1) (agent ?CONTEST ?AGENT2) (hasPurposeForAgent ?CONTEST ?PURP1 ?AGENT1) (hasPurposeForAgent ?CONTEST ?PURP2 ?AGENT2) (not (equal ?AGENT1 ?AGENT2)) (not (equal ?PURP1 ?PURP2)))))

The knowledge inference rule stipulates that each instance of Contest is carried out by two agents and each has his own non-equal purpose. This is exactly the source knowledge needed for the metaphor mapping. When the conceptual metaphor is linguistically realized, lexical expressions are then chosen to represent the conceptual terms of both purposeful agents, as well as conflicting purposes for the agents. Notice that in contest, as in economy, it is not necessary to have only one winner. There may be multiple winners and perhaps no winners. In other words, the agents' purpose may not be conflicting. But the purposes-for-agent are definitely different for each agent.

In addition to the 40 instances of economy metaphors involving contest, there are also 23 instances of metaphors involving War. In these cases, it is interesting to observe that the central concept is still the conflicting purposes (one's gain is another's loss) of the warring party. This is confirmed by the shared ontology. In SUMO, a War is a kind of ViolentContest, which in turn is a kind of Contest.

For example, in SUMO, the term War is defined as 'A military confrontation between two or more Nations or Organizations whose members are Nations.' Moreover, the term ViolentContest is defined as 'Contest where one participant attempts to physically injure another participant.' As can be seen from the definition and the metaphoric uses involving War, the ontological source domain knowledge is not involved.

In fact, when examined more closely, it is clear that when the domain knowledge of War is used, it either further specifies the conflicting purposes by elaborating on the quality and manner of the conflict, or elaborating on the agent participants as combatants. In other words, Economy is War is not a different mapping. It is subsumed under the mapping of Economy is Contest, with added elaborations on the participants.

By carefully examining the mapping from source domain knowledge based on SUMO, we discovered not only that mappings are indeed based on a priori source domain knowledge, we also discovered that a metaphor can often involve additional and more specified terms within a domain, as in the case of 'ECONOMY IS WAR.' In these cases, no additional mapping is required. The same structured domain knowledge is used, and the subsumed terms offers only elaborations based on the same knowledge structure.

5.2 Economy is Organism

An example where the knowledge system of SUMO ontology reminded us to re-think the structure of the source domain involves Organism. We arrived at this conclusion by re-examining the examples that we generalized as Economy is a Person in the previous section. After closer examination with the help of SUMO knowledge representation, we found that the linguistic realizations of this mapping do not involve any knowledge that is specific to Human. In fact, it only involves the notion of a life cycle, which is the defining knowledge involving an Organism.

Organism is defined in SUMO as 'a living individual, including all Plants and Animals.' The crucial knowledge that is encoded in of the attached inference rules is as follows:

=> (and (instance ?ORGANISM Organism) (agent ?PROCESS ?ORGANISM)) (holdsDuring (WhenFn ?PROCESS) (attribute ?ORGANISM Living)))

The above inference rule encodes the knowledge that 'An organism is the agent of a living process that holds over duration.' In other words, having a life cycle is the defining knowledge of an Organism. This turns out to be the source domain knowledge that is involved in the mapping.

It is interesting to note that since the mapping between two source domains to the same target domain are principled and constrained, *a priori*, our theory will predict that simultaneous mapping is possible when the mappings are compatible with each other. Since the Purpose of an Organism is to prolong his own life cycle, co-existing mapping of Economy is Organism and Economy is Contest would be possible if the PurposeForAgent is an Organism. We found that in actual linguistic data, such as in *jingji jiu shi luorou qiangshi* 'Economy is the strong feeding on the weak.' In other words, these complex knowledge systems can be combined to form more complex knowledge systems given appropriate conceptual constraints.

6. PARALLEL KNOWLEDGE SYSTEMS: *ECONOMY IS A TRANSPORTATION_DEVICE* IN CHINESE AND ENGLISH

We showed in the last section how a shared upper ontology could be used to formally represent a single complex system. In particular, we showed that the SUMO ontology can be applied to precisely capture the structured source domain knowledge that is being mapped to describe the target domain. In other words, the knowledge structure transfer from one domain to the other is successfully described. In this session, we go further to show that such a methodology can also be applied to account for parallel complex knowledge systems. In particular, we attempt to account for parallel, yet non-identical, metaphors in two different languages. We will account for the parallel metaphors of **Economy is a Transportation Device** in both Mandarin Chinese and English.

We will show in this section that, different knowledge structures can be mapped from the same source domain. In terms of information systems, this clearly shows that it is often not enough to know the domain of the information source. The proper knowledge structure of the information must be presented in order for it to be useful. We first show that the source domain of TransportationDevice is used in both Chinese and English to describe economy. Both languages use the same hierarchical source knowledge structure, incorporating the parent concept of motion, daughter concept of 'Transportation,' and the related concept of 'Transportation Device,' as illustrated by (6). However, the two languages choose two different entities to instantiate the concept of TransportationDevice.

6.1 The Data

After examination of extracted data in both languages, the English data from the WSJ Corpus and Chinese from the Sinica Corpus, we identify two source domains that are related. ECONOMY IS AN AIRPLANE in Chinese and ECONOMY IS A VEHICLE in English both belong to the domain of 'Transportation'.

From Tables 17-5 and 17-6, we notice that the source domain of AIRPLANE is used prototypically in Chinese to map a 'rising action' whereas the source domain of MOVING VEHICLE is used to map the 'speed' of movement in English economy metaphors. Examples of sentences for these metaphors are given in (2) and (3):

Table 17-5. ECONOMY IS AN AIRPLANE (Mandarin Chinese)
Mapping Principle: Economy is an airplane because an airplane ascends and an economy rises.

	Metaphors	Frequency
Functions	*qi3fei1*'to take off'	8
	fei1sheng1 'ascending (while flying)'	1
	tu1fei1 'sudden ascending (while flying)'	1

Table 17-6. ECONOMY IS MOVING VEHICLE (English)
Mapping Principle: The economy is a moving vehicle because moving vehicle has speed of movement and economy has speed of development.

	Metaphor	Frequency
Entities	slowdown	3
	track	2
	slowing	1
	turn	1
	turnaround	1
	driver	1
Quality	on track	2
	slower	1
	slowing	1
Functions	**to slow**	**11**
	slow down	3
	adding fuel	2
	to race	2
	speed	1
	turns around	1
	barreling down thee highway	1

(2) ECONOMY IS AIRPLANE (Chinese)

臺灣 經 了 經濟 起飛

taiwan jingli le jingji qifei

Taiwan experience ASP economy take off

"Taiwan has experienced a rise in its economy"

(3) ECONOMY IS MOVING VEHICLE (English)

a. the economy is going to **slow down** ,

b. the U.S. economy were **barreling down the highway** at 100 miles

In order to check whether these two related conceptual metaphors (in different languages) can be captured by a single structured ontology, we searched for the key concepts in the Mapping Principles for AIRPLANE and MOVING VEHICLE.

For example, when the key concept of 'ascend' was searched for ECONOMY IS AN AIRPLANE, the results from SUMO show that the concept of 'ascend' is defined as 'travel up' and it corresponds with the node of 'Motion,' which comprises the subclasses of 'BodyMotion,' 'Direction Change,' 'Transfer,' 'Transportation' and 'Radiating' (refer to Figure 17-3).

Among these subclasses, 'Transportation' possesses the following definition in (4), which corresponds with the source domain we have identified – i.e., AIRPLANE for 'ascend.'

(4) Motion from one point to another by means of a Transportation Device.

If trans is an instance of transportation, then there exists transportation device device so that device is an instrument for trans.

From Figure 17-3, although the related subclass of 'DirectionChange' is also under the Motion node, it is not on the conceptual branch linking Motion to Transportation and then to TransportationDevice. In other words, it is not directly related to the metaphor ECONOMY IS AN AIRPLANE. The prototypical occurrences of *qifei* 'take off' do not reflect 'DirectionChange;' rather, instead it refers to the motion of the transportation device.

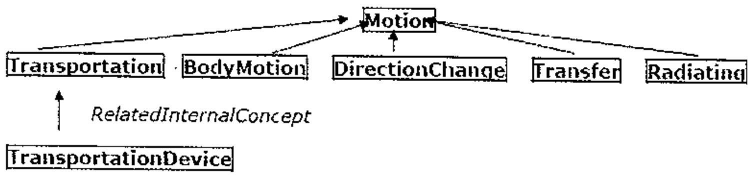

Figure 17-3. Nodes of 'Motion'

Hence, the ontological relations of the concept Transportation as referred to in the ECONOMY IS A AIRPLANE metaphor is more precisely shown in (5).

(5) Process

↑

Motion

↑

Transportation

↑ *RelatedInternalConcept*

TransportationDevice

Transportation is internally related to TransportationDevice. This relation is defined in (6) and the definition of TransportationDevice is given in (7).

(6) transportation is internally related to transportation device.

(relatedInternalConcept Transportation TransportationDevice)

(7) If *device* is an *instance* of *transportation device*, then *device* is *capable* to do *transportation* in role *instrument*.

(=> (instance ?DEVICE TransportationDevice)

(capability Transportation instrument ?DEVICE))

Therefore, the source domain of AIRPLANE in Mandarin Chinese has mappings corresponding to the node of 'TransportationDevice,' which is a lower node for 'Motion' in SUMO.

6.2 Economy is Moving Vehicle in English

We next searched for the concept of 'speed,' which is identified as the most prototypical mapping of ECONOMY IS A MOVING VEHICLE to study the knowledge domain comparison between Chinese and English economy metaphor. The concept of 'speed' is represented in SUMO as two separate linguistic functions, i.e., 'speed' as noun and verb. Their respective corresponding nodes for nominal and verbal readings are given in (8) and (9).

(8) Corresponding Nodes for Nominal 'Speed'

Motion

↑

BiologicallyActiveSubstance

↑

FunctionQuality

↑

RationalNumber

↑

SpeedFn(Function)

(9) Corresponding Nodes for Verbal 'Speed'

Motion

↑

RationalNumber

↑

Increasing

↑

NormativeAttribute

Among these nodes, 'Motion' reflects the majority linguistic expressions in Table 17-6, with the most prototypical mapping of 'slowing down.'

If the concept of 'speed' shares the similar corresponding nodes of 'Motion,' then its subclasses are predicted to be similar to the hierarchy shown in (6). Within this hierarchy, 'speed' also has a corresponding node with 'Transportation' and 'TransportationDevice.'

6.3 Implications: Inferring information from knowledge systems

In terms of the parallel metaphor 'ECONOMY IS A Transportion Device,' two different empirical prototypes are used: AIRPLANE is used in Chinese, and VEHICLE in English. They are mapped differently in Mandarin Chinese and English due to the conceptual variations between the two speech communities. The use of the car in the English speaking communities is similarly a general experience of life, which is mapped to the experience of a cyclical economy. The subsidiary function of 'Speed' represented in the metaphor can also be entailed with people's familiarity with the function of the car. Chinese speakers do not have the same relationship to cars as English-speakers. However, Chinese speakers do perceive both economy and airplane as tools towards modernization. Hence it is reasonable for them to use the more concrete image to describe the more abstract concept.

The findings discussed above have several implications: First, the source domain knowledge in a metaphor can be structured, instead of just an atomic conceptual node. This structure can be precisely captured by ontology, such as SUMO. Second, metaphors have strong conceptual motivation. Hence, even though that metaphors may be parochially realized with different terms in different languages, there is a good possibility that these terms may actually represent identical conceptual structure. This is shown in this paper with the contrast between English VEHICLE and Chinese AIRPLANE, both of which turn out to represent identically structured source knowledge. Third, while conceptual structures are shared, the choices in which subsidiary components may be instantiated may be motivated by the shared experience of the speakers of that language.

7. EXTENDING ONTOLOGY WITH WORDNET: MERGING KNOWLEDGE STRUCTURE FROM MULTIPLE SOURCES

An inherent dilemma of adopting a shared upper ontology is that it cannot cover all concepts. A shared upper ontology is designed to cover the full range of knowledge systems, and hence is restricted to these common conceptual roots. It must exclude idiosyncratic concepts and structures of individual systems. SUMO, for instance, is limited to no more than 1,000 concepts. However, the information systems that need to be captured far exceed these conceptual nodes. We propose to overcome this lack of variations by combing information from an upper ontology and a lexical ontology, such as a wordnet.

A wordnet is a semantic network consists of all lexical items from a language and linked by lexical semantic relations. The complete list of words from a language is basically a list of all the linguistically coded concepts in that language. We could take them to be the complete list of conceptual atoms used by speakers of that language. Since all things describable in that language can be reduced to a list of words as descriptive atoms, a wordnet is simply an ontology which has the widest coverage in that particular language. When a wordnet is linked to a shared upper ontology, the combined knowledge system enables comprehensive coverage of conceptual variants as well as uniform knowledge representation. The mapping between SUMO and WordNet by Niles [22] provided such an infrastructure. Further work has been done to expand this infrastructure to a bilingual one by the construction of Sinica BOW [17].

In terms of our corpus-based prediction of structure representation of the complex knowledge of metaphors, we have noted that it is often impossible to predict mapping to a SUMO node when there are not enough instances attested in the corpora. We examine two instances here that are not attested in the Sinica Corpus: LOVE IS A PLANT (Table 17-7) and LOVE IS FOOD (Table 17-8).

Table 17-7. LOVE IS PLANT Definitions from WordNet and SUMO

Items	WordNet Senses	Explanation	SUMO Category
mengya	**2: sprout**	grow sprouts, of a plant	Growth
miao	**1: seedling**	young plant or tree grown from a seed	FloweringPlant
zhang	**1: grow**	come to have, of physical features and attributes	Growth
guangai	**1: water**	pour water on	Wetting
kaihua	**1: bloom**	produce or yield flowers	Growth

Table 17-8. LOVE IS FOOD Definitions from WordNet and SUMO

Items	WordNet Senses	Explanation	SUMO Category
ziwei	**1: taste**	distinguishing a taste by means of the taste buds	Tasting
ku	**1: bitter**	one of the four basic taste sensations; sharp and disagreeable; like the taste of quinine	TasteAttribute
Weidao	**1: taste**	distinguishing a taste by means of the taste buds	Tasting
Chi	**1: eating**	the act of consuming food	Eating

Ahrens [7] proposes the following MP for LOVE IS A PLANT: "Love is understood as plant because plants involve physical growth and love involves emotional growth." Since corpora searches do not come up with any instances of this metaphor, it is difficult to ascertain the validity of this principle. We therefore propose looking at the 1) WordNet sense, 2) the WordNet definition and the 3) SUMO node for the WordNet sense for the intuition-based examples in order to see if there are any semantic overlaps within, or between, these three types of information. Table 17-7 shows that the word "Growth" appears three times in the SUMO category, out of the five examples. "Grow" also appears three times in the sense and definition

columns from WordNet. Thus, the combination of WordNet information and the SUMO representation agrees with the MP originally given.

In another example that has less than ten corpora examples, LOVE IS FOOD (Table 17-8), both the WordNet information and the SUMO information again matches up with the Mapping Principle suggested in Ahrens [17], that "Love is understood as food because food has different tastes as love involves different feelings." Table 17-8 shows that *taste* is mentioned five times in the WordNet sense and definition, and three out of four times in the SUMO category. Thus, determining the number of overlapping lexical items in WordNet definitions and SUMO categories to verify Mapping Principles seems to hold promise for instances where there are not enough examples to make a judgment based on frequency alone. This combinational approach can also be extended to economy-related metaphors (Table 17-9).

Table 17-9 shows that there are three instances of the concept of 'Invasion' found in the WN definitions, but they are all in the same definition. An alternate hypothesis is that 'ViolentContest' is the critical issue since it occurs in the SUMO nodes of two different words. In addition, in Section 5.1 (also in Ahrens et al. [28]), we noted that ECONOMY IS WAR is a subset of the ECONOMY IS CONTEST metaphor, with the MP of 'Economy is war because war involves a violent contest for territorial gain and the economy involves a vigorous contest for financial gain.' Moreover, the SUMO node of WAR is linked to ViolentContest. This example demonstrates that not only do we need to have an expansion of Sinica Bow to link to more items in WordNet, we also need to expand our notion of semantic space to include related SUMO nodes. In sum, our current analysis suggests that the previous MP was correct.

Table 17-9. ECONOMY IS WAR Definitions from WordNet and SUMO

Items	WordNet Senses	Explanation	SUMO Nodes
cinlue	**4: invasion**	the act of invading; the act of an army that invades for conquest or plunder	Violent Contest
zhan	**1: war**	the waging of armed conflict against an enemy	War
laobing	**1: veteran**	a serviceman who has seen considerable active service	SocialRole
Celue	**6: ambush**	the act of concealing yourself and lying in wait to attack by surprise	Violent Contest
xisheng	**1: sacrifice**	kill or destroy	Killing
xishengpin	**1: sacrifice**	personnel that are sacrificed (e.g., surrendered or lost in order to gain an objective)	Human

In order to further verify this point, the following discussion demonstrates that conceptual metaphors with the similar source domain of WAR show the similar mapping of the concept 'contest.' Table 17-10 gives instances of STOCK MARKET IS WAR. Although different lexical items are mapped as compared with ECONOMY IS WAR, the mapping of the concept of 'contest' is the same.

Thus, the proposed MP is the same; 'Stock market is war because war involves a violent contest for territorial gain and the stock market involves a vigorous contest for financial gain.' Note that although economy and stock market are two different *target* domains, they do have a conceptual relation. The stock market (referring to market activities) are one of the most typical and prominent processes in economy. Hence, it is a significant sub-type of the economy concept.

Table 17-10. STOCK MARKET IS WAR Definitions from WordNet and SUMO

Items	WordNet Senses	Explanation	SUMO Nodes
zhan	**1: war**	the waging of armed conflict against an enemy	War
celue	**6: ambush**	the act of concealing yourself and lying in wait to attack by surprise	Violent Contest
dilei	**1: land_mine**	an explosive mine hidden underground; explodes when stepped on or driven over	Weapon
guanka	**1: checkpoint**	a place (as at a frontier) where travellers are stopped for inspection and clearance	LandArea
fangwei	**2: defend**	be on the defensive; act against an attack	Contest
shanggong	**1: attack**	take the initiative and go on the offensive: "The Serbs attacked the village at night"	Contest
tiaozhan	**4: challenge**	a call to engage in a contest or fight	Requesting
cheli	**1: evacuation**	the act of evacuating; leaving a place in an orderly fashion; esp. for protection	Motion

8. SUMMARY AND IMPLICATIONS

In this chapter, we applied ontology to the study of the complex knowledge system of metaphors and showed that a shared upper ontology, such as SUMO, provides a framework to do formal and principled representation of the structured knowledge of the complex system. In addition, we showed that SUMO can be combined with a language wordnet to provide comprehensive coverage of all alternative conceptual variations.

The implications of such an approach can be illustrated by an example. The term 'soft landing' has recently become popular and is often collocated with China's economy. 'Hard-landing,' though not as popular, has similar distributions. Although it is possible to trace back the use of both terms to as early as Robert J. Gordon's 1985 article [29], it is also true that this expression never took root in daily English. Moreover, we only found one major dictionary, the 1996 Random House Unabridged Dictionary [30], listing the economy reading of soft-landing. However, these terms have been popular in Chinese for the past 20 years, since 1985, when the government made their first attempt to control inflation. And indeed, the term entered daily English use last year only when the Chinese premier made an announcement that China will micro-manage the economy to make sure inflation will not occur. On one hand, we can see that although the term is used quite early in English, the actual uses are restricted to very few academic papers. There is a very simple explanation for this. As we explored in the last couple sections, the metaphor mapping principle is Economy is an Airplane in Chinese, and Economy is Vehicle for English. Thus, even though the use of soft-landing can be understood both in Chinese and English, it became a frequent expression in Chinese. This is because this novel metaphor can be directly incorporated into the knowledge system of economy is an airplane. From web-based data, it is clear that when 'soft-landing' (or the less popular antonym 'hard landing') is used to describe economy in English, it highly collocates with references to the Chinese economy. For instance, 9 out of 10 highest ranked result of the Google search 'economy soft-landing' refer to China.

9. CONCLUSION

Ontology is powerful tools for building and integrating knowledge systems. Although our work is now highly dependent on manual human intervention, we can also make crucial use of computational ontology and electronic resources. We foresee construction of domain-specific ontology to be the next crucial step in this line of research. Construction of specific ontology can be semi-automated, especially with respect to the extraction of conceptual terms and their mappings to a shared upper ontology. When enough specific ontology is constructed, then a fully automatic integration of information can become a reality in the future.

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ON-LINE RESOURCES

Sinica BOW: Academia Sinica Bilingual Ontological Wordnet. http://BOW.sinica.edu.tw
Sinica Corpus: Academia Sinica Balanced Corpus. http://www.sinica.edu.tw/SinicaCorpus/
SUMO: Suggested Upper Merged Ontology. http://www.ontologyportal.org or http://ontology.teknowledge.com
WordNet http://wordnet.princeton.edu/index.shtml
WSJ Corpus: The Wall Street Journal Corpus. Accessed through the Linguistic Data Consortium http://www.ldc.upenn.edu/ldc/online/index.html.